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NOTES ON THE DISTRIBUTION AND ABUNDANCE OF DERMAPTERA AND STAPHYLINIDAE (COLEOPTERA) IN SOME COSTA RICAN CACAO PLANTATIONS

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Abstract.—The distribution and abundance of Staphylinidae (Coleoptera) and Dermaptera were studied in experimental microhabitats (rotting banana tree trunk sections, cacao pod husk-halves, cacao leaf litter, hanging cups filled with leaf litter) within two markedly distinct cacao plantation habitats in Costa Rica over a one-year period. Additional collections of both groups were taken in other cacao plantations. Distinctive patterns of distribution of both Staphylinidae and Dermaptera were found. Overall, Dermaptera were more abundant in rotting cacao pod husk-halves than in banana tree trunk sections, and the opposite true for Staphylinidae. Staphylinidae were markedly more abundant in the exposed cacao plantation in the dry season than in the forest, and the opposite true for Dermaptera. During the subsequent rainy seasons, these patterns were reversed. Virtually all samples were "dominated" by two species of Staphylinidae (always the same species) and three species of Dermaptera. Individual microhabitat pieces commonly contained both Dermaptera and Staphylinidae. Percentage (%) occupancy levels of microhabitats varied greatly with habitat and season for both groups. Overall, however, there was no statistically significant difference in the mean abundance of both groups, for both rotting banana tree trunk sections and cacao pod husk-halves, between the two habitats studied.

In this paper I report patterns of distribution and abundance for two groups of largely cryptozoic organisms (sensu Allee et al., 1949), Dermaptera and Staphylinidae (Coleoptera), in experimental "microhabitats" in some Costa Rican cacao ("cocoa") plantation habitats. Dermaptera and staphylinids are considered together in this paper since representatives of both groups frequently occur together in rotting organic debris in tropical habitats. The survey of insects described in this paper was based in large part upon the previous observation that Dermaptera species in Costa Rican cacao plantations often vary greatly in abundance among different microhabitats and times of the year (Young, 1984a). Relatively few studies have examined seasonal and microhabitat patterns of abundance in tropical cryptozoic insects and other arthropods (e.g. Lieberman and Dock, 1982; Irmler, 1979; Legner et al., 1981; Puig, 1980; Young, 1982, 1983a, b, 1984a). Phenological patterns of Staphylinidae have been documented for temperate-zone habitats (e.g. Levesque and Levesque, 1984; O. P. Young, 1984), but little has been documented for neotropical species.

Materials and Methods

These studies were conducted at the following Costa Rican cacao plantation localities: (1) "Finca La Tigra," near La Virgen (10°23'N, 84°07'W; 220 m elev.), Sarapiqui District, Heredia Province; (2) "C.A.T.I.E." at Turrialba (9°55'N, 87°02'W; 600 m elev.), Cartago Province; (3) "Finca Experimental La Lola," near Siquirres (10°06'N, 83°30'W; about 50 m elev.), Limon Province. The most extensive, systematic studies were conducted at the "La Lola" locality, where a short but intense dry season ("veranillo") usually occurs within February and March each year (Fig. 1).

The "La Tigra" and "Turrialba" studies were limited to checking replicated microhabitats during the dry season (1981 and 1982) for dermapterans and staphylinids. Insects were collected from various types of rotting, organic litter (banana tree trunk sections, cacao pod husks, cacao leaf litter, and plastic cups filled with leaf litter and suspended in cacao trees) (see also Young, 1982, 1983a, b, 1985). The "La Lola" study (1984) compared spepcies and their numbers for dermapterans and staphylinids in rotting banana trunk sections and cacao pod husks split in half lengthwise and distributed in two adjacent but markedly different cacao habitats. These two habitats, a "cacao forest" (abandoned cacao plantation), and a well-kept "cacao plantation" were very different in terms of the degree of permanent shade cover and the ground-cover vegetation beneath the cacao trees (Fig. 2). In the "cacao forest" a dense shade cover over the ground cover was provided by both self-shading cacao trees (50–60 years old and unpruned) and an overstory of principally *Huara crepitans* Linnaeus (Euphorbiaceae) (Fig. 2). The relatively broken and uneven shade cover in the adjacent "cacao plantation" habitat consisted chiefly of *Erythrina* sp. (Fabaceae); here, cacao trees, although of the same cultivated variety ("Matina") and age as the trees in the "cacao forest," were frequently pruned thereby reducing shade cover throughout the year. The general result of these habitat differences is that during the dry season, the *H. crepitans* shade in the cacao forest is greatly reduced due to the intense leaf-drop and the *Erythrina* sp. shade in the plantation less so.

In the "La Lola" study, three censuses of Dermaptera and Staphylinidae in rotting cacao pod husk-halves, banana tree trunk sections (see figures in Young, 1983a), leaf litter, and intact (whole) rotting cacao pods either on the ground or still attached to branches, were taken at widely-scattered intervals within a twelve-month period corresponding to "dry season" (March), "mid-rainy season" (August), and "late rainy season" (November). At each census, the following "microhabitat" pieces were collected from each of the two habitats (forest and plantation): 60 banana tree trunk sections, 75 cacao pod husk-halves, 350 cacao leaves, 35 arboreal rotting cacao pods, and 35 intact pods rotting on the ground beneath cacao trees. Approximately three months prior to each census, 125 banana trunk slices and 150 pods husk-halves were distributed in groups of five in each of the two habitats, their locations randomized by number-coded cacao trees. An additional five 1 × 1-meter wooden frames were similarly distributed in each habitat and filled with cacao leaves. Intact pods on the ground, and pods rotting on the trees, happened upon at each census were also examined for insects. Substrates were brought to a field station for removal of insects and recording of numbers per piece. From these observations a voucher collection was generated

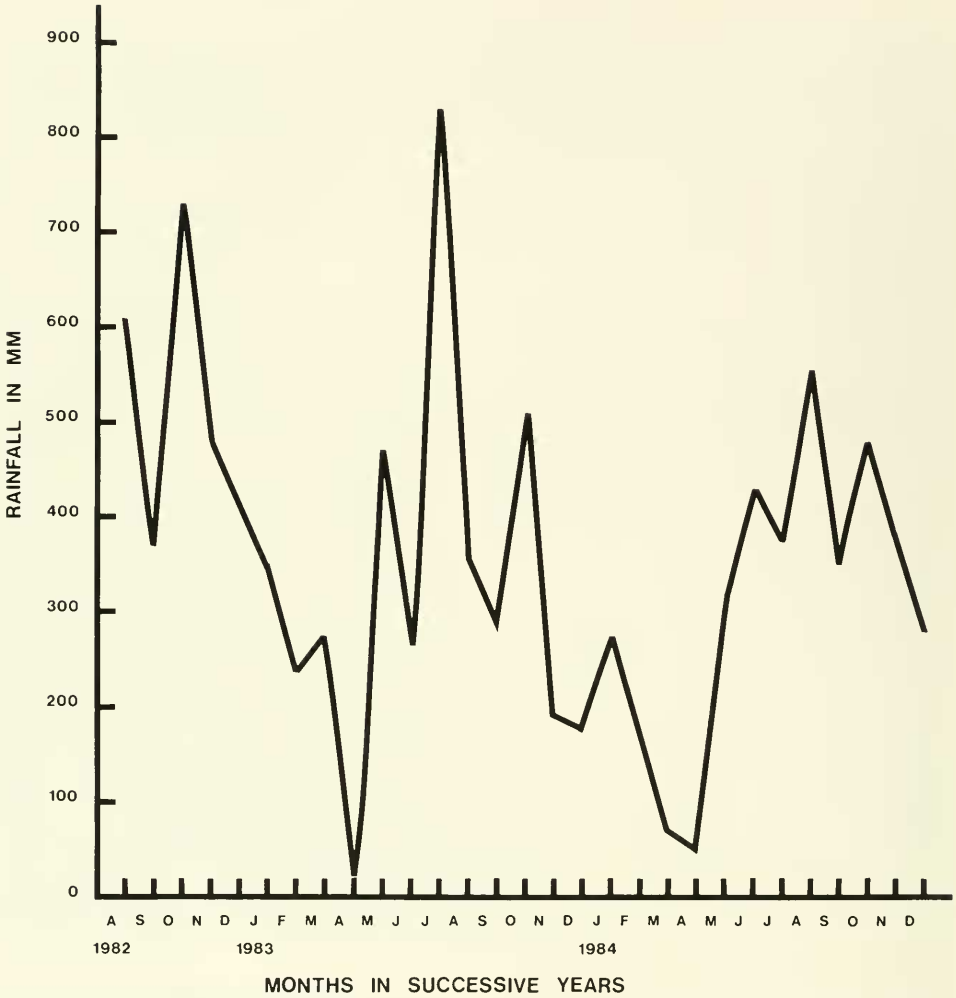

Fig. 1. Monthly rainfall pattern (in mm) for several successive years, including the study period, at "Finca Experimental La Lola." A dry season occurs each year between February and April.

and subsequent identifications to genera and species, when possible, were undertaken. A similar approach was used for collections at "La Tigra" and "Turrialba."

Results

A preliminary census of Staphylinidae alone for the dry season period at three widely scattered cacao plantations indicated that two species, *Belonuchus* nr. *mimeticus* and *Piestus sulcatus,* were the most abundant representatives at "La Lola" and "Turrialba" (Table 1). Most interesting from this preliminary survey was the discovery of *B.* nr. *mimeticus* in arboreal cup leaf litter, even though very scarcely so (Table 1). Thus *B.* nr. *mimeticus* occurred at more than one stratum within the cacao plantation habitat. *Parosus* sp. no. 1, exceedingly scarce species,

Fig. 2. Contrasting cacao habitats studied. Above: "cacao forest" showing cacao trees and trunk of a *Huara crepitans* (Euphorbiaceae) overstory tree. Below: open "cacao plantation" habitat at "La Lola." Note exposed cacao trees and grassy ground cover in the cacao plantation habitat.

Table 1. Summary of a preliminary survey of Staphylinidae associated with cryptozoic-type microhabitats at three cacao plantations in Costa Rica during dry seasons.

Locality	Census Date	Substrate Examined and % of Occupancy	Species	Numbers	% of Total Sample
"Turrialba" (C.A.T.I.E.)	17 Feb. 1981	banana tree trunk sections (5/300 = 1.7% occupied)	*Piestus sulcatus* Grav.	27	49.1%
			Belonuchus nr. *mimeticus* Sharp	14	25.5%
			Aleocharinae sp. no. 1	9	16.4%
			Medon sp. no. 1	2	3.6%
			Stilomedon sp. no. 1	1	1.8%
			Aleocharinae sp. no. 3	1	1.8%
		arboreal cup litter (1/22 = 4.5% occupied)	*B.* nr. *mimeticus*	1	1.8%
"La Lola"	10 Feb. 1981	banana tree trunk sections (48/240 = 20.0% occupied)	*B.* nr. *mimeticus*	33	33.7%
			P. sulcatus	65	66.3%
	11 Mar. 1982	banana tree trunk sections (2/240 = 0.8% occupied)	*B.* nr. *mimeticus*	30	69.8%
			P. sulcatus	12	27.9%
			Medon sp. no. 1	1	2.3%
"La Tigra"	5 Feb. 1981	banana tree trunk sections (1/240 = 0.4% occupied)	*Parosus* sp. no. 1	1	100.0%

was found at "La Tigra" and not at the other two localities. Previous collections of insects from rotting banana tree trunk sections in "La Lola" cacao plantation habitats included several species of carabid beetles: *Perigona laevigata* Bates, *Pentagonica maculicornis* Bates, and *Platynus orbicicollis* Chaudoir. While carabids were not collected in the present study, their numbers appeared to be very low in all samples.

About 56% of all Dermaptera (167/301) and about 54% (74/138) of all Staphylinidae collected in the "La Lola" study came from the plantation habitat. Such data suggest an even split of both groups of insects between the two habitats. Bias in such data may come from the preponderance of dermapterans over staphylinids in samples, since about 69% of all insects collected from banana tree trunk sections and cacao pod husk-halves combined were Dermaptera (301/439 insects).

For both habitats combined, 68.2% (204/299) of Dermaptera occurred in the cacao pod husk-halves, whereas the reverse pattern was true for Staphylinidae, in which 65.9% (91/138) occurred in the banana tree trunk sections. But these patterns change with habitat: for Dermaptera, 84.4% of all individuals collected occurred in cacao pod husk-halves in the "cacao forest" habitat; for Staphylinidae, 83.8% (62/74) occurred in banana tree trunk sections in the "cacao plantation" habitat. For both Dermaptera and Staphylinidae (Tables 2 and 3), there were no significant differences in the mean abundance of all species (summed) between forest and plantation habitats for population in rotting banana tree trunk sections (Student's $t = 1.224$, $P > 0.05$ for Dermaptera; $t = 1.126$, $P > 0.05$ for Staphylinidae). No significant differences were found for both groups in rotting cacao pod husks as well ($t = 0.834$, $P > 0.05$ for Dermaptera; $t = 0.899$, $P > 0.05$ for Staphylinidae). In spite of what appeared to be large differences in total abundances between habitats for a given microhabitat study (Tables 2 and 3), markedly different sample sizes obliterated any significant differences in the samples collected.

Percentages (%) of "occupancy" for banana tree trunk sections and cacao pod husk-halves also change with tropical season. Whereas about 40% of banana tree trunk sections were occupied by Dermaptera in the dry season census for the "cacao forest" and only 13.3% for the "cacao plantation," about the same percentages of occupancy were observed for cacao pod husk-halves between the two habitats (13.3% of husks in the "cacao forest" and 14.7% occupied in the "cacao plantation," respectively). Overall occupancy dropped sharply by the mid-rainy season (August) for banana tree trunk sections, but not so for cacao pod husk-halves: about 13.3% of the banana tree trunk sections were occupied by Dermaptera in the forest and 3.3% in the plantation. But more than three times the number of cacao pod husk-halves in the plantation had Dermaptera than in the forest (30.7% occupancy in the plantation and 10.7% occupancy in the forest habitat). This pattern for Dermaptera remained the same for the late-rainy season census (November): 13.3% of banana tree trunk sections were occupied in the "cacao forest" and none were occupied in the "cacao plantation." Almost four times the number of cacao pod husk-halves were occupied in the plantation than in the forest habitat at this time (44.0% occupancy for the "cacao plantation" and 12.0% for the "cacao forest").

For Staphylinidae, close to three times the number of banana tree trunk sections were occupied in the plantation than in the adjacent forest (41.7% and 15.0% respectively) during the dry season (March) census. About twice the number of

Table 2. Distribution and abundance of Dermaptera from replicated "microhabitat" substrates in two contrasting and adjacent cacao "habitats" in the eastern lowlands of Costa Rica for one complete cycle of dry season and rainy seasons.

Census Date	Species	Banana Tree Trunk Sections (Microhabitats) (N = 60 per habitat)			Cacao Pod Husk-Halves Microhabitats (N = 75 per habitat)			Total Insects; Substrates Combined
		N	% Total Sample	% Microhabitats Occupied	N	% Total Sample	% Microhabitats Occupied	
		"Cacao Forest"						
8–11 March 1984	*Carcinophora americana* (Beauvois)	14	29.2%	13.3%	10	27.0%	4.0%	24
	C. festiva (Burr)	22	45.8%	20.0%	19	70.4%	6.7%	41
	C. gagatina (Klug)	12	25.0%	6.7%	8	21.6%	2.7%	20
	Total	48		40.0%	37		13.3%	85
		"Cacao Plantation"						
	C. americana	6	25.0%	3.3%	12	35.3%	4.0%	18
	C. festiva	3	12.5%	3.3%	7	20.6%	2.7%	10
	C. gagatina	5	20.8%	1.7%	8	23.5%	4.0%	13
	Anisolabis maritima (Bonelli)	7	29.2%	3.3%	5	14.7%	2.7%	12
	Euborellia annulipes (Lucas)	3	12.5%	1.7%	2	5.9%	1.3%	5
	Total	24		13.3%	34		14.7%	58
		"Cacao Forest"						
8–12 Aug 1984	*C. americana*	1	9.1%	1.7%	2	14.3%	1.3%	3
	C. festiva	6	54.5%	6.7%	11	78.6%	8.0%	17
	C. gagatina	3	27.3%	3.3%	1	7.1%	1.3%	4
	E. annulipes	1	9.1%	1.7%	0	—	—	1
	Total	11		13.4%	14		10.6%	25
		"Cacao Plantation"						
	C. americana	0	—	—	12	32.4%	10.7%	12
	C. festiva	1	50.0%	1.7%	18	48.6%	13.3%	19
	C. gagatina	1	50.0%	1.7%	3	8.1%	4.0%	4
	A. maritima	0	—	—	2	5.4%	1.3%	2
	E. annulipes	0	—	—	2	5.4%	1.3%	2
	Total	2		3.4%	37		30.6%	39

Table 2. Continued.

Census Date	Species	Banana Tree Trunk Sections (Microhabitats) (N = 60 per habitat) N	% Total Sample	% Microhabitats Occupied	Cacao Pod Husk-Halves Microhabitats (N = 75 per habitat) N	% Total Sample	% Microhabitats Occupied	Total Insects; Substrates Combined
		"Cacao Forest"						
12–16 Nov 1984	*C. americana*	2	16.7%	3.3%	1	8.3%	1.3%	3
	C. festiva	8	66.7%	8.3%	10	83.3%	9.3%	18
	C. gagatina	2	16.7%	1.7%	1	8.3%	1.3%	3
	Total	12		13.3%	12		11.9%	24
		"Cacao Plantation"						
	C. americana	0	—	—	23	32.9%	12.0%	23
	C. festiva	0	—	—	—	—	—	
	C. gagatina	0	—	—	31	44.3%	21.3%	31
	Anisolabis maritima	0	—	—	9	12.9%	8.0%	9
	Euborellia annulipes	0	—	—	7	10.0%	2.7%	7
	Total	0		—	70		44.0%	
Forest—total insects (all species)		71			63			
Forest—total % occupancy		40/180 = 22.2%			27/225 = 12.0%			
Plantation—total insects		26			141			301
Plantation—total % occupancy		10/180 = 5.6%			67/225 = 29.8%			

Table 3. Distribution and abundance of Staphylinidae (Coleoptera) from replicated "microhabitat" substrates in two contrasting and adjacent cacao "habitats" on the eastern lowlands of Costa Rica for one complete cycle of dry season and rainy seasons.

Census Date	Species	Banana Tree Trunk Sections (Microhabitats) (N = 60 per habitat)			Cacao Pod Husk-Halves Microhabitats (N = 75 per habitat)			Total Insects; Substrates Combined
		N	% Total Sample	% Microhabitats Occupied	N	% Total Sample	% Microhabitats Occupied	
		"Cacao Forest"						
8–11 March 1984	*Belonuchus* nr. *mimeticus* Sharp	6	46.2%	5.0%	22	88.0%	16.0%	28
	Piestus sulcatus Grav.	4	30.8%	6.7%	3	12.0%	4.0%	7
	Stilomedon sp. #1	1	7.7%	1.7%	0	—	—	1
	Medon sp. #1	2	15.4%	1.7%	0	—	—	2
	Total	13		15.1%	25		20.0%	38
		"Cacao Plantation"						
	B. nr. *mimeticus*	23	43.4%	23.3%	6	60.0%	6.7%	29
	P. sulcatus	25	47.2%	13.3%	4	40.0%	4.0%	29
	Medon sp. #1	5	9.4%	5.0%	0	—	—	5
	Total	53		41.6%	10		10.7%	63
		"Cacao Forest"						
8–12 Aug 1984	*B.* nr. *mimeticus*	7	63.6%	10.0%	5	83.3%	4.0%	12
	P. sulcatus	4	36.4%	6.7%	1	16.7%	1.3%	5
	Total	11		16.7%	6		5.3%	17
		"Cacao Plantation"						
	B. nr. *mimeticus*	1	14.3%	1.7%	1	50.0%	1.3%	2
	P. sulcatus	3	42.9%	5.0%	1	50.0%	1.3%	4
	Medon sp. #1	2	28.6%	3.3%	0	—	—	2
	Apocellus nr. *barbatus* Sharp	1	14.3%	1.7%	0	—	—	1
	Total	7		11.7%	2		2.6%	9
		"Cacao Forest"						
12–16 Nov 1984	*B.* nr. *mimeticus*	4	80.0%	6.7%	4	100.0%	2.7%	8
	P. sulcatus	1	20.0%	1.7%	0	—	—	1
	Total	5		8.4%	4		2.7%	9

Table 3. Continued.

Census Date	Species	Banana Tree Trunk Sections (Microhabitats) (N = 60 per habitat) N	% Total Sample	% Microhabitats Occupied	Cacao Pod Husk-Halves Microhabitats (N = 75 per habitat) N	% Total Sample	% Microhabitats Occupied	Total Insects: Substrates Combined
		"Cacao Plantation"						
	B. nr. *mimeticus*	2	100.0%	3.3%	0	—	—	2
	P. sulcatus	0	—	—	0	—	—	0
	Total	2		3.3%	0			2
Forest—total insects (all species)		29			35			
Forest—total % occupancy		24/180 = 13.3%			21/225 = 9.3%			
Plantation—total insects		62			12			138
Plantation—total % occupancy		34/180 = 18.9%			10/225 = 4.4%			

Table 4. Comparative abundances of Dermaptera species among tropical season censuses, for both habitats and microhabitat-types combined.

Species	Numbers of Individuals in Different Seasons: Dry Season	Mid-rainy Season	Late-rainy Season	Subtotal Rainy Season	Overall Total	Species % of Total Sample
Carcinophora festiva (Burr)	58	36	18	54	112	36.4%
C. americana (Beauvois)	42	15	26	41	83	26.9%
C. gagatina (Klug)	33	8	34	42	75	24.4%
Anisolabis maritima (Bonelli)	12	2	9	11	23	7.5%
Euborellia annulipes (Lucas)	5	3	7	10	15	4.9%
Totals by seasons:	150	64	94			
% total by seasons:	48.7%	20.8%	30.5%			

cacao pod husk-halves were occupied in the forest than in the plantation at the same time of the year (20.0% and 10.7%, respectively), a reverse pattern from banana tree trunk section occupancy. While overall levels of occupancy for both banana tree trunk sections and cacao pod husk-halves were dramatically reduced at the mid-rainy season census, so too were differences between habitats: for banana tree trunk sections, 16.7% occupied in the forest and 11.7% in the plantation; for cacao pod husk-halves, 5.3% occupied in the forest and 2.7% in the plantation. Sample sizes were also reduced in the late-rainy season, although almost twice the number of banana tree trunk sections were occupied in the forest than in the plantation (8.3% and 3.3%, respectively). For cacao pod husk-halves, 2.7% were occupied in the forest and none were occupied in the plantation at this time.

Both "cacao forest" and "cacao plantation" habitats support similar arrays of species for both Dermaptera and Staphylinidae (Tables 2 and 3). Yet more than twice the number of dermapterans were found in exactly the same microhabitat samples than staphylinids for both habitats combined (i.e. 301 Dermaptera and 138 Staphylinidae) (Tables 2 and 3).

For Dermaptera in particular, more species were found in the March 1984 dry season census then in the two rainy season censuses, and within the dry season, a few more species were found in the "cacao plantation" than in the "cacao forest." Dermapterans and staphylinids frequently "co-occurred" in the same banana tree trunk sections and cacao pod husk-halves. In a few instances, two species of Dermaptera were found in the same microhabitat piece, although close to 90% of all such pieces examined for the entire study had only one species of Dermaptera per piece.

Staphylinidae exhibited markedly different levels of abundance among the three census periods. 59.4% of all Dermaptera in the dry season (85/143) occurred in the "cacao forest" habitat, 39.1% in the same habitat (25/64) in the mid-rainy season and only 25.5% in this habitat (24/94) at the late-rainy season census. Overall, 47.5% of all Dermaptera were from the single dry season census (143/301 insects). Only during the dry season census were Dermaptera markedly more abundant in the "cacao forest" habitat; in the other two censuses, these insects were more abundant in the "cacao plantation" habitat.

62.4% of all Staphylinidae during the dry season (63/101) occurred in the "cacao

Table 5. Comparative abundances of Staphylinidae species among tropical season censuses, for both habitats and microhabitat-types combined.

Species	Numbers of Individuals in Different Seasons: Dry Season	Mid-rainy Season	Late-rainy Season	Subtotal Rainy Season	Overall Total	Species % of Total Sample
Belonuchus nr. *mimeticus* Sharp	57	14	10	24	812	58.7%
Piestus sulcatus Grav.	36	9	1	10	46	33.3%
Medon sp. no. 1	7	2	0	2	95	6.5%
Stilomedon sp. no. 1	1	0	0	0	1	0.7%
Apocellus nr. *barbatus* Sharp	0	1	0	1	1	0.7%
Totals by seasons:	101	26	11	37	138	
% total by seasons:	73.1%	18.8%	8.0%			

plantation." But the subsequent pattern of abundance of staphylinids in the plantation habitat followed that for Dermaptera in the "cacao forest" habitat: 34.6% of staphylinids occurred in the plantation at the mid-rainy census, and only 18.2% occurred in the same habitat at the late-rainy season census. The dry season census alone accounted for 73.2% (101/138) of all Staphylinidae counted in the "La Lola" study, suggesting an even greater response to the dry season by staphylinids compared to dermapterans.

For both Dermaptera and Staphylinidae, the tropical dry season period (March) coincided with the greatest numbers found in rotting banana tree trunk sections and cacao pod husk-halves (Tables 4 and 5). For all three censuses, 0–2 individuals of Dermaptera (*Carcinophora festiva, C. americana,* and *C. gagatina* accounted for almost 90% of all individuals censused, and with *C. festiva* being the most abundant (Table 4). Two species of Staphylinidae, *Belonuchus* nr. *mimeticus* and *Piestus sulcatus,* comprised more than 90% of the entire sample size in the "La Lola" study (Table 5).

Both Dermaptera and Staphylinidae occurred in rotting, intact (whole) cacao pods on the ground and attached to branches (hanging pods) in both dry and rainy seasons (Table 6). While comparable numbers of Staphylinidae were found in forest and plantation habitats, about twice as many Dermaptera occurred in intact cacao pods in the plantation habitat than in the forest (Table 6). Two species of Staphylinidae, again *B.* nr. *mimeticus* and *P. sulcatus,* comprise the total fauna for this group in intact pods, both on the ground and still attached to branches (Table 6). The same three species of Dermaptera so abundant in the banana tree trunk sections and cacao pod husk-halves were the sole representatives of this group in the intact pods (Table 6). Occupancy levels of both groups were two or three times higher for pods on the ground than hanging cacao pods in the same stages of decay (Table 6). The overall percentages of total faunas (numbers of individuals) for both groups were not as high as they were for banana tree trunk sections and cacao pod husk-halves (Tables 4–6).

Discussion

These data suggest that experimentally distributed rotting banana tree trunk sections and cacao pod husk-halves are equally suitable environments for various species of Dermaptera and staphylinid beetles. These substrates, as well as others

Table 6. Distribution of staphylinid beetles and Dermaptera in rotting substrates* in cacao habitats, other than banana tree trunk sections and pod husks.

Habitat	Date	Substrate-type	N	Staphylinids		Dermapterans	
				Species	Numbers	Species	Numbers
Cacao Forest	11 March 1984	hanging rotten pods	35	*Belonuchus* nr. *mimeticus* Sharp	2	*Carcinophora festiva* (Burr)	3
Cacao Plantation	11 March	hanging rotten pods	35	*B. mimeticus*	1	*C. festiva*	1
Cacao Forest	11 March	rotting pods on ground**	30	*Piestus sulcatus* Grav.	3	*Carcinophora gagatina*	
				B. mimeticus	2	(Klug)	1
Cacao Plantation	11 March	rotting pods on ground	30	*B. mimeticus*	1	*Carcinophora americana*	
				P. sulcatus	6	(Beauvois)	2
						C. gagatina	6
						C. festiva	4
Cacao Forest	12 Aug 1984	hanging rotten pods	35	*B. mimeticus*	1	*C. festiva*	2
Cacao Plantation	12 Aug	hanging rotten pods	35	none	—	*C. festiva*	2
Cacao Forest	12 Aug	rotting pods on ground	30	*P. sulcatus*	3	*C. festiva*	2
Cacao Plantation	12 Aug	rotting pods on ground	30	*B. mimeticus*	2	*C. gagatina*	3
				P. sulcatus	4		
Cacao Forest	14 Nov 1984	hanging rotten pods	35	*B. mimeticus*	3	*C. festiva*	2
				P. sulcatus	4		
Cacao Plantation	14 Nov	hanging rotten pods	35	*B. mimeticus*	2	*C. festiva*	1
Cacao Forest	14 Nov	rotting pods on ground	30	*P. sulcatus*	5	none	
Cacao Plantation	14 Nov	rotting pods on ground	30	*P. sulcatus*	4	*C. festiva*	2

Total staphylinids in forest: 27 (individuals) 2 (species)

Percent staphylinid occupancy of hanging rotten pods: 13/210 = 6.2% (habitats combined)
Percent staphylinid occupancy of rotting pods on ground: 30/180 = 16.7% (habitats combined)

Total staphylinids in plantation: 20 (individuals) 2 (species)

Total Dermaptera in forest: 10 (individuals) 2 (species)
Total Dermaptera in plantation: 21 (individuals) 2 (species)

Percent Dermaptera occupancy of hanging rotten pods: 11/210 = 5.2% (habitats combined)
Percent Dermaptera occupancy of rotting pods on ground: 30/180 = 16.7% (habitats combined)

Percent staphylinids in dry season census: 15/44 = 34.1% (habitats combined)

Percent Dermaptera in dry season census: 15/29 = 51.7% (habitats combined)

* Individual pods with range of 0–3 individuals for both staphylinid beetles and Dermaptera.
** These are mature or near-mature pods, rotted largely by fungus diseases and cut off tree, intact by plantation workers.

studied, represent naturally occurring microhabitat for cryptozoic insects in Costa Rican cacao plantations. Yet the degree to which these microhabitats are occupied by staphylinids and dermapterans varies at different times of the year, and by habitat. Although I failed to find statistically significant differences in the mean abundance levels between habitats for both groups of insects, perhaps a result of small sample sizes, the data suggest that the *direction* of change in abundance between habitats is different between the groups.

The tendency for a few species to occur most commonly in samples, for both staphylinids and dermapterans, is not unexpected. The immature stages of a few species of ceratopogonid midges (Diptera) comprised the major portion of midge immatures in both rotting banana tree trunk sections and cacao pod husks at the same locality (Young, 1983a). As observed here for a few species of staphylinids, it was not uncommon to find the same ceratopogonid species in both terrestrial and arboreal microhabitats (Young, 1983a).

Cacao plantations in the Atlantic watershed region of Costa Rica generally have a broken, irregular shade cover and spongy leaf litter, factors perhaps related to the overall suitability for occupancy by staphylinids and dermapterans. Many cryptozoic insects require both shade and rotting organic debris (Allee, 1949).

Because dryness of decaying, terrestrial litter in cacao plantations is often a major determinant of insect distribution occupying litter substrates (e.g. Tawfik et al., 1976; Lieberman and Dock, 1982; Young, 1982, 1983a, b, 1984), differences in degree of shade cover, and its response to the tropical dry season between two adjacent or nearby habitats can generate different distributional patterns of cryptozoic insects, as indicated by my data. During the dry season, the shade trees in the forest habitat (chiefly *Huara crepitans*) drop their leaves, exposing both the understory cacao trees and ground cover to direct sunlight and drier conditions. Such an effect is less marked in the nearby cacao plantation (Young, 1984b). During the tropical dry season, rotting banana tree trunk sections retain moisture and become ecological micro-refuges for some insects (Young, 1983a). Because greater numbers of Dermaptera were found in rotting banana tree trunk sections in the forest habitat in the dry season than in the plantation, and the opposite pattern was found for staphylinids, it is evident that these groups respond in different ways to cycles of tropical seasonality.

A previous preliminary survey of Dermaptera between sunny and shaded habitats at "La Lola" revealed dramatic increases in densities in banana tree trunk sections in the dry season (Young, 1984a). In that study, three species, *Anisolabis maritima, Euborellia annulipes,* and *Marava triqueta* Hebard, together comprised about 25% of all samples from "La Tigra," "Turrialba," and "La Lola." Further comparative study of the natural history of both groups may elucidate why such markedly different distributional patterns exist. The general observation, also evident from my data, of both groups being less abundant in all substrates studies, during the rainy-season samples, suggests a more broad distribution of breeding populations of individual species at these times of the year. Both species number and abundance of individual species of insects often changes markedly in tropical habitats between seasons (e.g. Bates, 1945; Dobzhansky and Pavan, 1950; Owen and Chanter, 1970; Bowden, 1976; Buskirk and Buskirk, 1976; Irmler, 1979; Denlinger, 1980; Young, 1980a, b, 1981).

During the dry season at "La Lola" relatively higher densities of various insects

occur in rotting banana tree trunk sections and cacao pod husk-halves (see also Young, 1982, 1983a, b). Some of these insects include Collembola, ants, and immature stages of various Diptera. Such insects may be suitable prey for Staphylinidae. Staphylinids may comprise one group of predatory insects capable of withstanding unfavorable periods of dryness in being generalist predators on various other organisms (e.g. Becker, 1975). Dermaptera in general exhibit considerable ecological flexibility in adapting to changing environmental conditions (e.g. Good, 1982; Miller, 1984), and therefore can thrive in moist microhabitats in both dry and rainy seasons in the tropics. While little is known about the precise feeding habitats of the staphylinids studied here, undoubtedly some, such as *Piestus* spp., are principally saprophagous or symbiotic wood-feeders (P. Hammond, pers. comm.). Others, such as *Belonuchus* and *Medon,* as well as the Aleochorinae represented in my samples, are predators on other arthropods (P. Hammond, pers. comm.). Being generalized scavengers on a broad range of rotting organic materials (e.g., O. P. Young, 1984 and several included references), dermapterans may be generalized decay-product feeders within the rotting microcosm of banana tree trunk sections and pod husk-halves. Dermaptera and Staphylinidae may use rotting banana tree trunk sections and cacao pod husks as breeding sites. The dermapteran *Carcinophora americana* (Beauvois) guards clutches of bright yellow eggs within the wall tissues of rotting cacao pod husks (based on one observation, A. M. Young).

The degree to which a microhabitat (substrate) is occupied by either staphylinids or dermapterans indicates the relative suitability of that microhabitat within the habitat. Thus the markedly high overall abundance of Dermaptera in the forest and their low abundance in the plantation suggests that the forest was more suitable for those species thriving in rotting banana stems. But the reverse was true for dermapterans in cacao pod husk-halves. Thus the net effect was an overall equal abundance of Dermaptera and between the two habitats, even though their distribution between the two microhabitat-types studied (banana tree trunk sections and cacao pod husks) was inversely-related.

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